ESCIRRU
Economic and Social Consequences
of Industrial Restructuring in Russia and Ukraine

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ESCIRRU Working Paper No. 12

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Berlin, October 2009

ESCIRRU • A European Research Project Funded by the 6th Framework Programme and Managed by DIW Berlin

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January 2010

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We thank Lenina Akkineni for valuable research assistance and Natalia Karchenko at KIIS for most helpful advice on the dataset. We are grateful to Martin Kahanec, participants at the IZA workshop on "Analysis of Labour Market Adjustment in Transition and Emerging Economies Using Large Micro-Data Sets", the ESCIRRU conference in Moscow and at seminars at the LSE, the University of Bologna, DIW Berlin and the University of Manchester for helpful comments. Lehmann also acknowledges financial support by the European Commission within the project "Economic and Social Consequences of Industrial Restructuring in Russia and Ukraine" (ESCIRRU).

Abstract

Using longitudinal data from the Ukraine we examine the extent of any long-lasting effects of radiation exposure from the Chernobyl disaster on the health and labour market performance of the adult workforce. One in six prime-age Ukrainian adults report being in poor health, a much higher figure than comparable estimates from many western industrialised countries. The variation in the local area level of radiation fallout from the Chernobyl accident is considered as a random exogenous shock with which to try to establish the causal impact on poor health, labour force participation, hours worked and wages. There appears to be a significant positive association between local area-level radiation dosage and perception of poor health, though much weaker associations between local area-level dosage and other specific self-reported health conditions. There is also some evidence to suggest that that those more exposed to Chernobyl-induced radiation have significantly lower levels of labour market performance twenty years on.

Key words: Chernobyl, Health, Labour Market Performance

JEL Classification No. H00, J00

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On 26th April 1986, engineers at the Chernobyl nuclear power plant in the Ukraine began a series of tests on one of the nuclear reactors that lead to the world's worst civil nuclear disaster. The amount of radiation released as a consequence of the accident was far in excess of that released from the air bursts of the Hiroshima or Nagasaki atomic bombs, hitherto the focus of much research and knowledge about the consequences of radiation fallout. Yet, while much has been written, and argued, about the medical and physical consequences of Chernobyl[1], less attention has been given to the social and economic consequences of the disaster, despite recent urgings along this line from the United Nations, (UNDP 2002). Since there are now movements in many industrialised countries toward building a new generation of nuclear power facilities, knowledge of any long-term economic consequences of such rare, low frequency events as an accident in a nuclear power plant is important.

Understanding the link between environmental shocks, health and economic performance and establishing an appropriate policy response is important. Faced with a large-scale accident, state resources are almost certainly diverted away from other programmes in order to deal with the immediate consequences of the disaster and this may affect the future pattern of development and growth unless mitigated by international aid. Equally, the subsequent performance of individuals may have been impaired directly in some way by the disaster. Investigating the relationship between this, health and economic performance then helps illuminate the costs of this accident.

There is also a growing literature concerned with the long-term consequences of environmental shocks, summarised recently in Almond (2006) or Maccini and Yang (2008),

[1] For example, Chernobyl Forum (2005) puts the total number of Chernobyl cancer related deaths at 4000. Greenpeace (2006) cites a figure of around 90,000 cancer related deaths with an additional 100,000 from other radiation-related illnesses.

where shocks can have lasting effects on both health and on other economic outcomes that affect long-run economic performance. There may also be issues of long latency of certain conditions that can only be observed with data taken some years after the initial event. Health has also long been considered to be a potentially significant determinant of labour market outcomes, such as wages, hours of work and employment, (see the references in Lleras-Muney (2005), Currie and Madrian (1999), Strauss and Thomas (1998), Kahn (1998)). Much of the literature is concerned with the difficulty of establishing a causal link between health and performance.

In what follows, we examine the relationship between exposure to radiation as a result of the Chernobyl accident and both subsequent health and economic performance fifteen to twenty years later using longitudinal data on a sample of individuals from the Ukraine. Since radiation fallout was rather randomly distributed across the Ukraine, given the prevailing wind patterns at the time and mobility was strictly controlled under the Soviet Union, we treat radiation exposure as an exogenous shock and first look to see whether there is any association between the level of radiation dosage in the local area of residence at the time of the disaster and a variety of self-reported health measures some seventeen years or more after the event.

One important existing study uses a similar exogenous source of environmental variation. Almond, Edlund and Palme (2007) use regional variation in Chernobyl-related radiation dosage across Sweden to look at the association between educational attainment at age 18 and differential exposure to the fallout of those who were in utero at the time of the accident. They find evidence indicative that cognitive ability of those *in utero* may well have been impaired as a result. Our study looks for evidence of radiation associated longer-term effects on a variety of *health* outcomes of individuals of all ages living in the country at the source of the accident, where, arguably, awareness and the environmental legacy were most profound and where relatively high radiation levels affected a larger share of the population than any other country with the possible exception of Belarus. To this day, more than half of the adult Ukrainian population appears to be concerned over the consequences of this event.[2] One in six prime-age Ukrainian adults also report being in poor health, a much higher figure than comparable estimates from many western industrialised countries.

Access to longitudinal data can facilitate identification of any causal examination of the effects of early shocks on later socio-economic achievement. The Ukraine is fortunate in this regard since there is a panel data set, the Ukrainian Longitudinal Monitor Survey (ULMS), which has self-reported health and socio-economic data for a representative sample of individuals at, currently, three points in time, 2003, 2004 and 2007, and which also allows us to establish the place of residence of respondents at the time of the Chernobyl accident. The set of covariates allow us to control for a set of possible observable cofounders. The longitudinal nature of the data allows us to control for unobserveable characteristics.

Other studies have looked at longer-term effects of shocks on individual economic eprfromance. Almond (2006) exploits the 1918 influenza epidemic to examine long run consequences for educational attainment and labour market performance. Meng and Xiang (2006) use regional level variation in the 1959-61 Great Famine in China as an exogenous shock to identify health effects on individual economic performance. Miguel & Roland (2006) look at how variation in area-level bombing in the Vietnam war, using distance from the 17th parallel as an instrument for the intensity of bombing, affected area-level consumption, literacy and economic performance thirty years on. Concerns over the exogeneity of any shock have been addressed by others analysing different events. Chay and Greenstone (2003) use the recession-induced variation in area level pollutants to try to identify the effects on child mortality. Maccini and Yang (2008) look at the consequences of geographical variation in early-life rainfall on the subsequent health and educational attainment of individuals across Indonesian birth cohorts. Kling, Lieberman and Katz, (2007) look at long-term health effects of a set of individuals randomly assigned to a set of U.S. neighbourhoods with differing levels of economic

[2] The ULMS data used in this study show that in 2003, 58 percent of the adults in the sample believed that their health or that of a family member had been affected by Chernobyl.

performance, finding no physical health effects, but positive mental health effects of assignment to advantaged neighbourhoods.

One advantage of our approach is that we are given information on an individual's settlement of residence in the Ukraine around the time of the accident. It is therefore possible to assign a settlement-level radiation dosage to establish the association between this dosage and the subsequent health of the adult workforce. There was widespread variation in the amount of radiation areas received. Some areas in the Ukraine received little more radiation then normal background levels, while other areas received more than ten times the usual background level dosage. We focus on the potential long-term health impacts of the population of working age. This could also potentially provide an instrument to identify the causal impact of health on labour market performance across age groups or different sub-groups of the population. The first step then is to establish whether there is a link between local area level radiation dose received and the list of illnesses recorded in the ULMS. The second step is to see whether radiation dose itself is correlated with other observable socio-economic outcomes over the next twenty years. Finally we look to use whether local area level radiation dosage can be considered as an instrument for the effect of health on a range of labour market and income generating outcomes that are important for daily life in the Ukraine.

We then proceed to look whether knowledge of radiation dosage can help identify the causal effect of health on labour market performance. Better health may allow better quality of education and productivity at work. Equally, better education may facilitate better health. As such it has long been known that OLS estimation of the effects of poor health on economic performance would tend to be biased down if there is a negative correlation between unobservables that determine work and poor health.[3] Strauss and Thomas (1998) suggested that local environmental conditions can act as a potential instrument for health, since conditional on

[3] This would be offset by any measurement error in the measure of health.

health, individual productivity and performance should not be affected by environmental conditions.

Our results show that there is a significant positive effect of residence in radiation affected areas at the time of the accident and self-assessed poor health. Adults living in areas considered to have received sufficiently high radiation fallout as to be continually monitored are up to 10 percentage points more likely to report being in poor health. However, there is a less obvious manifestation of such an effect on a variety of specific self-reported health conditions. This suggests that the main long-term health effect of Chernobyl for the majority of the current adult population may be working through perceptions. In the second half of the paper we explore whether area of residence at the time of Chernobyl affects labour market performance twenty years later and whether it could be considered as a good instrument for health perceptions in wage and employment equations.

Our paper has the following structure. Section 2 outlines the methodology used in this study along with details of the Chernobyl accident. Section 3 describes the data, while Section 4 discusses the results that while OLS estimates of the effect of exposure to Chernobyl and poor health on the probability of working, the likelihood of home production of foodstuffs, of informal working, hours worked and on wages. A final section concludes.

2. Methodology

In what follows, we argue that exposure to radiation from Chernobyl constitutes an exogenous "treatment". The treatment depends partly on the distance from the reactor - though not monotonically since there are several radiation "hotspots" at varying distances from the reactor caused by changes in the wind direction, differential rainfall levels and local topography across areas. In practice, the proxy for this treatment that we focus on is based on the local area radiation level exceeding a specific threshold. The treatment level may also depend on the individual's age at the time of the accident. For example, children who were 0-4 years old at the time of the accident are known to have been particularly vulnerable to thyroid cancer from exposure to radioactive iodine. Indeed the rising incidence of thyroid cancer amongst children has been one of the main demonstrable health impacts of Chernobyl (WHO 2006).

UNDP (2002) shows however that the range of radiation related illnesses is not restricted to cancers. Reports of lung diseases (bronchitis, emphysema), digestive and blood disorders, birth defects, immune deficiencies, fertility problems are all reported to be correlated with exposure to the irradiated areas, (see also Greenpeace 2006). Moreover, exposure to Chernobyl induced radiation can be chronic for many due to continued internal irradiation from consumption of foodstuffs grown in contaminated ground or from leakage of radio-nuclides into ground water from the "graveyards" used to store intermediate waste immediately after the disaster, but unmarked and untreated subsequently. In short, continued exposure to radiation and the long latency period of many of these illnesses suggest the potential existence of long-term "at-risk" populations in the affected areas.

Any study that tries to identify the effects of Chernobyl by comparing groups exposed to more radioactivity than others has to address possible confounding issues. The treatment may generate an endogenous response because, as with the Chernobyl disaster, governments put resources into the most affected areas and individuals (MNS 1991). The Ukrainian government did indeed enact a series of sliding scale interventions regarding compensation, pension, health, housing and education for those deemed to have undergone *severe* exposure to radiation, namely residents within the 30km evacuation zone around the plant, along with clean-up workers and their immediate family. So, it is possible that later-life outcomes may be affected by the subsequent interventions as well as the initial treatment. However the random pattern of radiation makes it less likely that fallout, for the majority of individuals, was concentrated in areas that had worse employment prospects relative to others. It is true that the authorities did engage in environmental amelioration in other heavily irradiated areas outside the evacuation zone. It is conceivable therefore that these interventions may have influenced the development of these areas and, hence, the subsequent economic performance of the individuals residing in these areas. Our subsequent results should be considered with this in mind.

There may be concerns over sorting of individuals across high and low radiation areas. If those better able to react were concentrated in high radiation areas this may bias any Chernobyl effect on health downward. The rather random nature and control over residency makes sorting and residential choice before the event less likely, but it is true that individuals may have moved away from the irradiated areas after restrictions on mobility were relaxed following the fall of the Soviet Union. However this will only affect chronic exposure to radiation and not the initial exposure. If anything this will work to bias any health effects downward. Comparing treatment effects across cohorts can be problematic because of the difficulty of separating the effect of the treatment from other events over time. In what follows we control for a variety of exclusion restrictions, individual and area characteristics in an effort to minimise these confounding effects. The use of longitudinal data may also allow us to control for unobservable effects that could otherwise bias the estimation process.

Measuring Fallout

Radiation fallout from Chernobyl has been measured mainly (Ministry of Emergencies of Ukraine 2006) by the presence of the two radioactive isotopes of most concern to the monitoring authorities – radioiodine (^{131}I) and radiocaesium-137 (^{137}C). Young children were thought to be particularly at risk of thyroid problems following exposure to ^{131}I, found initially in the air and then in contaminated milk . However since it has a half-life of only 8 days the population at risk is likely to vary from that exposed to ^{137}C , which has a half-live of around 30 years and as such carries a more persistent legacy. Consequently, and also because of the fact that its persistence makes it easier to measure, this is the radiation dosage that we use in our analysis. Background levels of ^{137}C before the accident, principally the legacy of nuclear weapons testing by the Soviets in neighbouring Kazakhstan after the Second World War, were estimated at 2 kilo Becquerel (kBq/m^3). While almost all areas of the Ukraine received radiation doses in excess of levels observed before the accident, (see Table 1 for the ULMS sample estimates), areas where exposure levels to ^{137}C were in excess of 1480 kBq/m^3 were subject to immediate evacuation.

Following the accident, changes in wind direction, wind speed, local rainfall, allied to the degree of forestation, urbanisation and topography in the locality all contributed to the variation in fallout as document by the pattern of ^{137}C deposits in Figure 1. This pattern of dispersal was rather random, making it less likely that radiation was concentrated in areas of worse employment prospects. If anything, the fact that the majority of the affected areas are in the vicinity of Kiev where all measures of labour market performance are far better than in the rest of the country (Lehmann, Kupets and Pignatti (2005)) would suggest the opposite. Nevertheless, Figure 2 makes clear that exposure to fallout is rather more random than a simple measure of distance from Chernobyl would suggest.

Some 50,000 individuals living in areas with radiation greater than 1480 kBq/m^3 were evacuated within a month of the accident. The majority of evacuees were sent to Kiev, Zhitomir and Chernigov, areas which themselves had received lower, but non-negligible, radiation doses. Individuals resident in other "highly contaminated territories" – those that received between 555 and 1480 kBq/m^3 - were not moved to purpose built towns such as Slavutich until after 1986 (IAEA 2006), which because of the pattern of disposition were again also contaminated by (lower but significant levels of) fallout from Chernobyl. It is this population and these areas that were eligible for government assistance. However, exposure in excess of 37 kBq/m^3 was considered to be high and areas of contamination that received such dosages were subject to monitoring by the Soviet Authorities and continued to be so by the Ukrainian successor governments (European Commission 1998).

In total, government assistance schemes were targeted at an estimated 800,000 adults, comprising "liquidators" – often military conscripts – who were involved in the clean-up process, the Chernobyl plant workers, the evacuees from the 30km exclusion zone, those living in highly contaminated territories and any children of these adult populations. The liquidators and plant workers were the group estimated to be exposed to the highest radiation dosages, followed by the inhabitants of the 30km exclusion zone, (IAEA 2006). Since 1986 it has become apparent that radiation dosages have fluctuated both across and within areas over time because of differences in topography or climate.[4] As a result some areas where the initial dosage was relatively light have received larger cumulative dosages than areas where the initial exposure was relatively high. Its particular concentration in forested areas has consequences for those consuming mushrooms, berries and game taken from contaminated areas. Potential health risks over and above background radiation from direct exposure to the radiation cloud include continued inhalation/consumption of contaminated particles/foodstuffs, consumption of forest food and time spent outdoors. In short, continued exposure to radiation and the long latency period of many of these illnesses suggest the existence of long-term "at-risk" populations. Our measure of radiation might be thought of as a combination of these acute and chronic effects.

3. Data

We use in our analysis the 2003, 2004 and 2007 waves of the Ukrainian Longitudinal Monitor Survey (ULMS), a longitudinal survey of initially 4,300 households and approximately 8,800 individuals aged 16 and over, undertaken for the first time in the spring of 2003.[5] As far as we are aware these are the only available individual data for any country that allow us to measure both contemporaneous health outcomes and personal characteristics along with the individual's location in 1986. A household questionnaire contains items on the demographic structure of the household, its income and expenditure patterns together with living conditions. An individual questionnaire elicits detailed information concerning both the labour market experience of

[4] Effective radiation doses are measured in millisieverts, (mSv). The average annual worldwide dose of background radiation is around 2.4mSv (IAEA (2006)). The IAEA estimates that liquidators received accumulated doses of around 100mSV over three years and residents of the monitored areas received, on average, between 10-30 mSV over twenty years. This represents an annual effective radiation dose around 1mSV over and above normal background doses.

[5] This constitutes a 0.02% sample of the adult population of 40 million.

workers in the Ukraine and on, self-defined, health status and specific health conditions, height and weight.[6]

Alongside detailed socio-demographic and income information, the ULMS data also contain responses to a basic question on health status which appears in both surveys "How would you evaluate your health?", to which the possible responses are : very good, good, average, and bad. There is a long-standing debate about the efficacy of using self-reported health measures, particularly ordinal variables which purport to measure an individual's overall perception of their health. Issues of comparability of subjective measures across individuals abound alongside the "justification" hypothesis that sees these variables as rationalisations for a given economic status, such as absence from work. IAEA (2006) suggests that the psychological rather than the physical legacy of Chernobyl may ultimately be more important. If so, then perceptions of health would be as likely to be correlated with perceived exposure to radioactivity from Chernobyl as the actual dosages received. In this way the determinants of self-reported health status may be a relevant variable to examine.

The ULMS also asks individuals to report whether they had any of fourteen specific health conditions, listed in Table 3, an assessment of whether they have had any health problems in the last 3 months along with measures of height, weight, drinking and smoking. We use these outcomes alongside the self-reported health status measure.

With regard to the issue of Chernobyl, there is a question in the 2003 ULMS which asks respondents where they were living in December 1986, the year of the Chernobyl disaster. The responses allow us to pinpoint the location to the nearest village. Some 760 settlements are identified among the list of responses.[7] Given this information we can map in the radiation dose the settlement is estimated to have received in April 1986 according to EC/ICGE (2001) which

[6] See Table 2 for the full set of self-reported conditions available in the survey. Baker et al. (2004) offer evidence to suggest that specific self-reported health conditions suffer from much the same measurement error and justification biases as self-reported overall health.

[7] This includes residence outside the Ukraine. Some 5% of the adult sample were living outside the boundaries of present- day Ukraine in 1986.

provide detailed “contour maps” of ^{137}C deposits in May 1986 for each country in Europe. Given this we can generate variables that measure the initial dosage – at the settlement level - and the cumulative dosage, between discrete intervals twenty years apart, at the level of the raion, the next level of area aggregation up. Since there may be non-linearities in response by dosage and there are radiation thresholds that trigger interventions, we also generate dummy variables to group radiation dosages into very high (in excess of 37 ^{137}C kBq/m^3) and the rest.[8] We can also identify individuals living in the monitoring zones at the time of the accident and generate a dummy variable to denote residence in these areas in 1986. We also compute a variable measuring the linear distance of the 1986 settlement from Chernobyl.

We then observe individuals and their children 18 to 21 years later and examine their circumstances conditional on the radiation dose received around the time in which they were living at the time of the accident. Since the young and those in the womb appear to be more vulnerable to radiation exposure, (Almond et al (2007)), we can interact the dosage with age at the time of the accident. We can, in principle, identify those who were in utero at the time of the accident, but the sample size for this group is small (144 and just 11 in the monitored raions) and the set of labour market related potential outcomes that can be measured is limited given that none of these children will have graduated from high school by 2003. Instead we focus on the adult population as a whole, in particular those of prime age since we are interested in the association between health and labour market outcomes, although we look to see whether those individuals who were children at the time of the accident respond differently to adults in the affected areas.[9]

Since we only have information from December 1986, we miss sampling the area of residence of the 50,000 or so residents who were living within 30km of the plant and who were evacuated before the end of 1986. Place of residence in the Soviet Union was strictly controlled

[8] Note that the 1986 dosage variable is by construction time invariant.
[9] The official retirement age for pension receipt in the Ukraine is 55 for women and 60 for men, though individuals in certain occupations can retire earlier than this.

and as such it is unlikely that other individuals could have moved without permission from the authorities. Nevertheless, the behaviour of the group subject to evacuation and subsequent attempts at compensation, may be different from those not evacuated, it is important that we can isolate the two groups in our data set. For example, it is known that special treatment was given to both evacuees and liquidators including extra schooling, welfare supplements, additional health care checks and assisted holidays, (Ministry Of Ukraine of Emergencies (2006)) all of which may affect subsequent outcomes of interest. However, the 2007 wave of the ULMS does contain information that allows us to identify anyone who was evacuated because of Chernobyl and whether this was in 1986 or later.[10]

Similarly we can identify the liquidators, for whom area of residence at the time of Chernobyl is less important than the radiation dose they received as a consequence of the clean-up operations. We can also identify those in receipt of "Chernobyl assistance" welfare payments. The proportion of the sample in receipt of this payment is less than 1 per cent, the majority of whom are evacuees or liquidators. Because of concerns that these groups will confound the analysis we separate those in the sample known to have been on military service, liquidators, Chernobyl pensioners or those who were evacuated in 1986. [11] The data is however subject to any survivor bias that may be caused by early deaths in the contaminated zones. A recent United Nations backed report (Chernobyl Forum 2005) estimated that the number of extra deaths resulting from Chernobyl across Ukraine, Belarus and Russia at 4000. While this number is disputed, (Greenpeace 2006), it seems unlikely then that survivor bias will influence our results unduly.

Table 1 documents the dispersion of estimated dosages. Most (66%) individuals in the sample were living in areas that received an (immediate) dose of less than 10 kBq/m^3 of ^{137}C.

[10] Given the nature of the Soviet Union, it is highly unlikely that any other members of the population could have moved or were allowed to move at this time.

[11] The correlation between poor health and Chernobyl pension receipt is negative and that between poor health and liquidator status is positive. The median, tenth and ninetieth percentiles of the age distribution are not statistically significantly different across the contaminated and other zones. Attrition from the panel does not appear to be associated significantly with residence in the contaminated zone. See Table A6 for estimates of the observable determinants of attrition from the sample.

The median settlement-level dosage is 7 kBq/m^3. Just over 4% of the sample was resident in areas that exceeded the 37kBq/m^3 monitoring threshold and 8% were resident in the monitor zones. Around 22% of adults in the sample and some 17% of the working age adults say that they are in poor health. These estimates are rather high compared to those from the industrialised West.[12] The persistence of the poor health variable is outlined in Tables A2 and A3 of the appendix. While the proportion reporting poor health is quite stable over time, the persistence of poor health status is somewhat lower. Around 50% of the sample report being in poor health in two successive waves and around 40% are in poor health in both 2003 and 2007. Most of those initially in poor health in the 2003 wave who report a change in status move into the average health category, though, interestingly, the reverse movement does not appear to hold over time.

The labour market related data contained in the ULMS allow us to observe whether an individual is in employment, the number of weekly hours worked, the log of monthly wages and whether the individual is engaged in growing foodstuff for consumption.[13] Mean values of these and some of the other covariates used as controls in the analysis are also given in Table 1. Around 60% of the prime age adult sample is in work and working, on average, some 41 hours a week. Around 38% of the working age sample are engaged in production of own foodstuffs, indicative of the legacy of the transition economy on individual activity. Around 3% of the sample work in the informal sector. Some 0.8% of the sample of adults in 2003 appear as liquidators and 0.6% of the sample classify themselves as evacuees.[14]

4. Results

Table 2 shows the results of the first stage of the estimation process, examining whether there is a link between self-reported poor health and Chernobyl-related radiation exposure. The Table gives linear probability estimates of the effect of four different Chernobyl-related variables – settlement

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[12] The 2007 Health Survey for England suggests equivalent percentages of 7.3% and 5.1% respectively. The 2003 US National Health Interview Survey gives equivalent estimates of 3% and 2% respectively.

[13] We make no attempt to control for the effect of wage arrears on monthly wages. There is no evidence from our data that living in the contaminated zone is correlated with the 12% incidence of wage arrears among those in work.

[14] 0.2% of the sample were evacuated in 1986.

level dosage, a dummy variable for residence in an area where the dosage exceeds the 37KbQm^2 threshold, a dummy variable for residence in a designated contaminated area and a measure of the distance in kilometres of the settlement from the Chernobyl reactor.[15] The set of controls include a quadratic in age, dummies for educational attainment of both the individual and that of their parents, controls for gender, ethnicity, whether the individual is left handed, foreign language proficiency and religion. To account for any systematic area effects that may be correlated with the pattern of fallout and area economic performance, there are also dummy variables for residence in the capital, its outlying oblast and residence in the south, east and west of the country.[16] The top panel presents estimates for the first year of the survey, 2003 and the bottom panel gives the estimates from a random effects regression for the pooled three year sample.[17] We present estimates for all adults aged 16 and over and a set of prime age adults aged 23 to 59.

For both samples of adults, there is a significant positive association in 2003 between poor health and area level dosage – whether measured by settlement-level dosage, the dummy variable for residence in 1986 in a designated contaminated zone or by the dummy variable for residence in 1986 in areas that received in excess of 37 ^{137}C kBq/m^3. The effects are strongest for the contaminated zone dummy and for prime age adults.[18] Prime age adults living in a contaminated raion in 1986 were some eleven percentage points more likely to report being in poor health in 2003 than those who were living elsewhere in 1986.[19] Only the measure of distance from the Chernobyl plant is not associated with self-declared poor health. The pooled random effects estimates of the Chernobyl variables are still positive and significant, particularly for the prime age sample, but somewhat attenuated.

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[15] Identification of causal effects is not hindered by a binary dependent variable and 2SLS estimates are always consistent no matter whether the first stage is linear or not, Angrist (2000).

[16] The default region is therefore the North excluding Kyiv.

[17] We are obliged to use random effects estimation to control for unobserved heterogeneity since the radiation dosage variables are fixed over time.

[18] The estimated coefficient on the dosage variable suggests that residence in an area that received 70KBqm^3 – the top 5th percentile of dosage – would be some 6 points more likely to report being in poor health than someone living in an area that received a zero dosage.

[19] The full set of covariate estimates are given in Table A4 in the appendix.

There may of course be heterogeneity around these average estimates. The dispersal of the fallout was such that different groups of the population were exposed to different levels of radiation that varied by geography, population density and age. Table 3 therefore reports the results from interactions of different variables with the Chernobyl area radiation measure. Since there are documented medical conditions among those who were children at the time of the accident, the first column reports the results from interaction with a dummy variable indicating whether the individual was less that thirteen at the time of the accident. The results suggest that this sub-group, now in their twenties, are significantly less likely, around 7 percentage points in the panel, to report being in poor health than others living in the radiated areas at the time. The interactions of the contaminated zone dummy with a quadratic in age also suggests that differences in perception of poor health between those in and those outside the contaminated zones at the time of the accident rise with age and then subsequently decline.

Individuals living in contaminated zones at the time of the accident may not have remained there forever. Although everyone in one area will have received, broadly, the same radiation dose at the time of the accident, lifetime exposure will depend, among other things, on length of residence in the contaminated area. While the data do give a complete set of residential moves over the period there are no disaggregated area-level time series data on levels of radiation with which to map to subsequent location. We therefore generate a single dummy variable for any change of residence and interact this with the Chernobyl variable. The results are given in the last two columns of Table 3 and show no significant difference in reporting of poor health status between movers and stayers. Other results, not shown here, indicate that there are no differential effects of the Chernobyl-related variable if the sample is split by distance from Chernobyl, rural or urban location, level of educational attainment or by gender.[20]

Other Health Outcomes

[20] If we interact the mover dummy with cumulative raion-level dose there is no significant effect of the interaction term. Results for other sample splits are available on request.

Table 4 replaces the self-reported poor health dependent variable with the set of other health conditions identifiable in the ULMS data set, using the same controls as in Table 2. We also add measures of height, BMI, smoking and drinking behaviour to the set of outcome variables. Once again we present estimates from the first cross-section of the survey and from the pooled three year random effects model. Each entry in the Table represents the coefficient on residence in the contaminated zone from a regression on the outcome given. Without exception the estimates for the radiation related variable are statistically insignificant in the 2003 cross-section.[21] Since it may be argued that the self-reported poor health variable is proxying an accumulation of illnesses rather than a single complaint, we check to see whether the contaminated zone variable is associated with proxies for the aggregation of the set of illnesses in the data. Again we find no significant effect of residence whether the outcome variable is "any health problems" or when we add all the health conditions from heart problems to tuberculosis. Nor does obesity, being underweight, drinking or smoking be related to the Chernobyl variables.

The random effects estimates however do give a significant positive effect of residence in the contaminated zone on gastro-intestinal illness and a significant negative effect on heart disease. In order to check the robustness of these results we repeat the random effects estimation for heart disease and gastro-intestinal illness using the other radiation-related measures reported in Table 2. The results, given in Table A4, show no significant association when these other radiation measures are used.

Taken together, these results therefore suggest that the most common association between Chernobyl and health related outcomes some twenty years later appears to be manifesting itself mainly through a negative effect on the health perceptions of working age adults rather than through any of the other demonstrable health outcomes available in the data set.

Reduced Form Estimation

[21] Danzer and Weisshaar (2009) report a significant negative association between well-being and an individual's assessment that "their health or that of a family member" had been affected by Chernobyl.

Table 5 presents the results of the reduced form estimates, both single cross-section and random effects, of the effect of Chernobyl-related radiation on employment, wages, hours of work, and the probabilities of being in informal work or of growing agricultural produce at home. We present estimates for both residence in the contaminated zone and residence in the designated monitoring areas. In the 2003 cross-section, while the point estimates on the Chernobyl variables are generally of the expected sign, in the same direction as those for poor health in Table 2, the estimates are not always significant. There do appear to be statistically significant negative effects of residence in the contaminated zone on hours of work. Residents in these areas work around two to three hours less than others. The random effects estimates do show significant negative effects on the probability of being in work and on the likelihood of informal work in addition to the negative effects on hours revealed in the cross-section estimates. The panel estimates suggest that residents living in the affected areas in 1986 are some six to seven percentage points less likely to be in work than those living elsewhere at the time of the accident.

Having set out the estimates of the direct effect of Chernobyl-related residence on labour market performance, we next look to see whether radiation-related variables are associated with other known potential correlates of labour market performance. If we are to consider using radiation exposure as in instrument for health in an employment or wage equation, it is helpful to try to establish that health is the main effect through which radiation exposure would affect labour supply or wages, since it could conceivably affect other variables known to be associated with labour market performance such as fertility, marital status or education. Any correlation between the intended instrument and these other potential explanatory factors may compromise the validity of the identification exercise.

To this end, Table 6 presents the estimated effects of residence in the contaminated zone in 1986 on educational attainment, number of children, marital status and mobility history for 2003 and for the panel from 2003 to 2007. There is no evidence that residence in the contaminated zone is associated significantly with marital status, educational attainment or number of children. However residence in the contaminated zone, but not in the high dosage areas, does appear to be negatively associated with subsequent mobility, both any move, and between-region mobility. This suggests that individuals are therefore not moving away from any perceived danger, rather the contrary. Indeed the system of residential control imposed under Soviet times would render it highly unlikely that individuals could have moved without permission from the authorities. As such the documented evacuations are the only major sources of mobility likely to have been undertaken in the first few years following the accident at Chernobyl. This latter result suggests that the Chernobyl-variable may be influencing average behaviour not only through its apparent effect on the health perception of the working age population.

5. Conclusion

The evidence presented above appears to suggest that the Chernobyl accident carries a long lasting legacy for many residents of the Ukraine, notably because of its effect on the perception of their health. One in six prime-age Ukrainian adults report being in poor health, a much higher figure than comparable estimates from many western industrialised countries. Adults living in areas considered to have received sufficiently high radiation fallout as to be continually monitored are up to 10 percentage points more likely to report being in poor health. However, there is a less obvious manifestation of such an effect on a variety specific other self-reported health conditions or risky behaviours. While the Chernobyl liquidators, much more exposed to radiation than other members of the population do appear to have experienced more longer-term health conditions, it seems that the main long-term health effect of Chernobyl for the majority of the current adult population may be working through perceptions.

There do appear to be significant associations with Chernobyl related residence and subsequent labour market performance. There is also some evidence to suggest that that those more exposed to Chernobyl-induced radiation have significantly lower levels of labour market performance twenty years on. If residence in the monitoring zone works through health perceptions this could be used to identify the effect of self-reported poor health on the probability of employment, wages or other activities that generate income and/or subsistence for the Ukrainian population. While there is also little evidence from the data used here that residence in a contaminated zone has influenced fertility or marriage behaviour, there is some evidence to suggest that mobility may be reduced among those living in areas that received higher doses of radiation in 1986. As such it may be hard to argue that poor health perceptions is the sole channel through which Chernobyl manifests itself, thus limiting IV estimation.

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Figure 1. Distribution of Radiation Fallout Across Ukraine, April 1986

(Source: Office for Official Publication of the European Community 2001)

Figure 2. Settlement –Level Initial Dosage (^{137}C k/Bq m^{3}) ULMS Sample

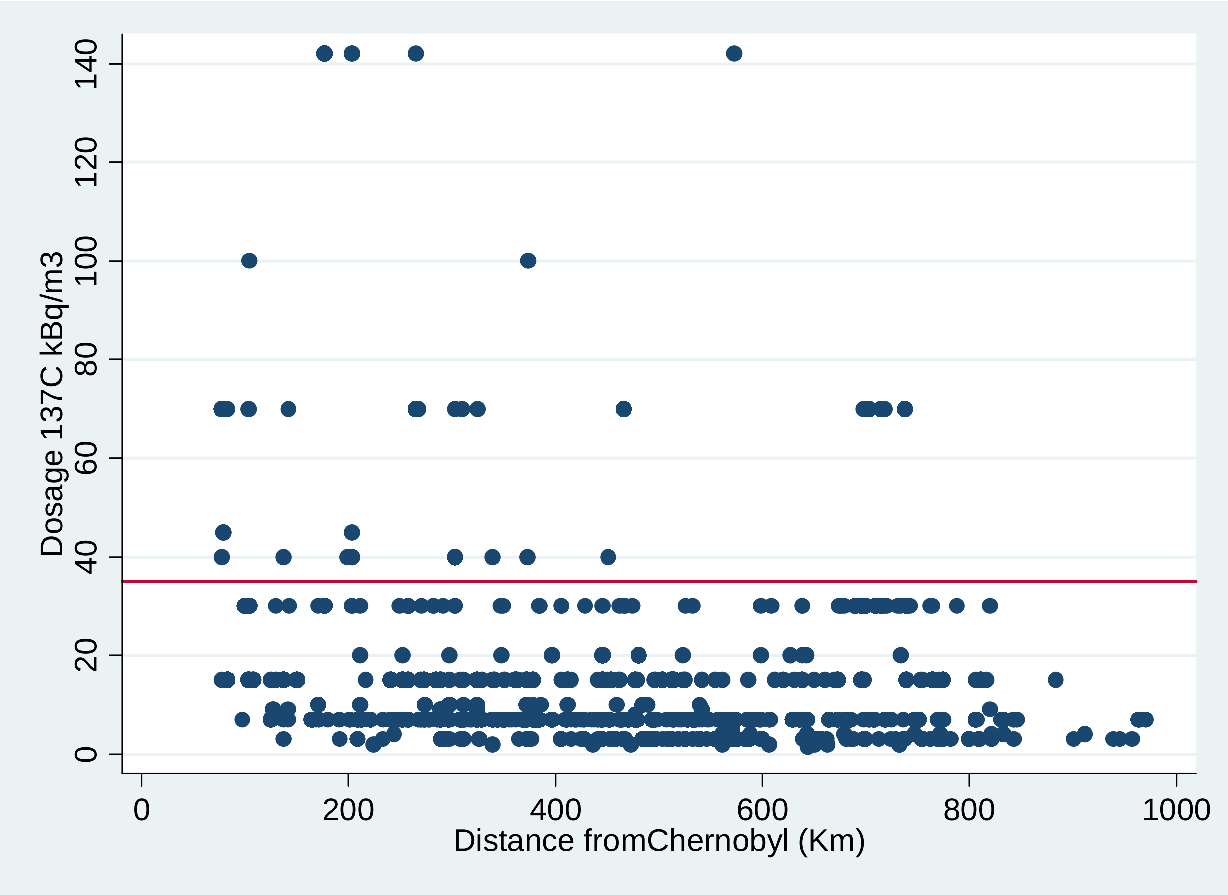

Table 1. Sample distribution of Radiation Dosage & Other Characteristics, 2003

	Percent		
Dosage ^{137}C kBq/m^3			
<4	22.2	In Work (Age 16+)	42.9
4-10	46.2	In Work (Age 23-59)	66.1
11-34	27.4		
35-99	3.7	In Bad Health (Age 16+)	22.1
99+	0.5	In Bad Health (Age 23-59)	16.9
Monitor Area	7.5	Actual Weekly Hours>=0	26.2 (22.6)
Monitor Area*Age<13	2.2	Actual Weekly Hours>0	41.8 (12.9)
Liquidator	0.8		
Evacuee	0.6	Gross Monthly Wage (Hrv)	309 (220)
Female	56.8	Informal Work	3.4
		Self Employed	5.3
Age 16-24	17.9	Own agricultural prodn.	38.2
Age 25-44	33.7		
Age 45-60	27.7		
Age 61+	20.7	Mother_graduate	8.2
		Mother_High school	29.2
Kyiv	5.0	Father_graduate	9.8
		Father_ high school	28.1
University	12.8		
Technical Diploma	40.0	Orthodox	61.6
High School	18.5	Other religion	19.3
Russian	16.7		
Other	3.8		

Note: Sample ULMS 2003. Standard errors in brackets.

Table 2. Self-Reported "Bad" Health & Chernobyl Exposure

	Age 16+				Age 23-59			
	1	2	3	4	1	2	3	4
2003								
Distance (100 Km)	-0.00060				-0.00045			
	(0.00098)				(0.00096)			
Dosage (KBqm^2)		0.00079				0.00083		
		(0.00032)*				(0.00035)*		
Area Dosage>37 KBqm^2			0.070				0.074	
			(0.021)*				(0.029)*	
Monitor Area 1986				0.053				0.110
				(0.023)*				(0.027)*
N	8363	8363	8363	8363	5286	5286	5286	5286
Random Effects								
Distance (100 Km)	-0.0001				0.0001			
	(0.0001)				(0.0001)			
Dosage (KBqm^2)		0.00048				0.00073		
		(0.00024)*				(0.00030)*		
Area Dosage>37 KBqm^2			0.028				0.047	
			(0.018)				(0.022)*	
Monitor Area 1986				0.037				0.052
				(0.017)*				(0.021)*
N	19257	19257	19257	19257	12363	12363	12363	12363

Notes; Source ULMS. Each regression controls for age, gender, religion, education, education of parents, ethnicity and region. Pooled data are random effects estimates. *= significant at the 5% level. Standard errors on distance and dosage clustered at settlement level.

Table 3. Estimated Effects on Poor health by Sub-Group

	2003	Panel		2003	Panel		2003	Panel
Monitor Area	0.123 (0.029)*	0.063 (0.021)*	Monitor Area	-0.347 (0.299)	-0.402 (0.212)	Monitor Area	0.124 (0.029)*	0.052 (0.020)*
Monitor Area *Under 13 in 1986	-0.094 (0.037)*	-0.068 (0.026)*	Monitor Area *Age	0.021 (0.016)	0.024 (0.011)*	Monitor Area *Moved since	-0.060 (0.048)	0.005 (0.038)
			Monitor Area *Age^2	-0.00023 (0.00021)	-0.00029 (0.00014)*			
Under 13 in 1986	0.004 (0.021)	0.033 (0.016)*				Moved since	-0.004 (0.011)	-0.007 (0.009)
Age	-0.0051 (0.0064)	-0.0036 (0.0047)	Age	-0.0062 (0.0041)	-0.0107 (0.0031)*			
Age^2	0.00016 (0.00007)*	0.00015 (0.00005)*	Age^2	0.00017 (0.00005)*	0.00023 (0.00004)*			

Table 4. Linear Probability Estimates of Health Conditions & Chernobyl Exposure 2003 (Age 23-59)

	Health Status	***Any Health last 3 months***	***Smoke***	***Drink***	***Heart***	***Lung***
2003						
Monitor Area	0.063	0.037	-0.045	-0.006	-0.039	0.009
	(0.045)	(0.032)	(0.026)	(0.029)	(0.022)	(0.014)
	Liver	***Kidney***	***Gastrointestinal***	***Spine***	***Other***	***Diabetes***
Monitor Area	0.015	0.030	0.044	0.010	0.026	0.007
	(0.022)	(0.020)	(0.026)	(0.023)	(0.027)	(0.008)
	Heart Attack	***Blood Pressure***	***Stroke***	***Anemia***	***Tuberculosis***	***BMI***
Monitor Area	0.002	-0.006	0.007	0.011	0.002	0.076
	(0.003)	(0.023)	(0.007)	(0.014)	(0.003)	(0.321)
	Height (cm)	***Obese (BMI>30)***	***Underweight (BMI<19)***	***Amount Drink***	***Amount Smoke***	$\sum_{i=heart}^{tuberc.} health_i$
Monitor Area	-0.003	0.016	0.021	0.009	-0.717	0.111
	(0.004)	(0.026)	(0.014)	(0.108)	(0.476)	(0.076)

Notes; Source ULMS. Each regression controls for age, gender, religion, education, education of parents, ethnicity and region. Means of dependent variables are 0.468 (any health problems), 0.327 (smoke), 0.667 (drink), 0.144 (heart problems), 0.051 (lung problems), 0.084 (liver), 0.074 (kidney), 0.131 (gastrointestinal), 0.119 (spine), 0.013 (diabetes), 0.168 (“other”), 0.010 (heart attack), 0.150 (blood pressure), 0.010 (stroke), 0.036 (anaemia), 0.006 (tuberculosis), , 25.5 (BMI), 1.69m (Height), 0.155 (obese), 0.041 (underweight).

Table 4b. Random effects Linear Probability Estimates of Health Conditions & Chernobyl Exposure (Age 23-59)

	Health Status	*Any Health last 3 months*	*Smoke*	*Drink*	*Heart*	*Lung*
2003, 2004, 2007						
Monitor Area	-0.027	0.025	-0.037	-0.030	-0.047	0.004
	(0.042)	(0.026)	(0.024)	(0.024)	(0.019)**	(0.011)
	Liver	***Kidney***	***Gastrointestinal***	***Spine***	***Other***	***Diabetes***
Monitor Area	0.017	0.020	0.043	-0.006	0.027	0.002
	(0.019)	(0.016)	(0.021)**	(0.019)	(0.021)	(0.007)
	Heart Attack	***Blood Pressure***	***Stroke***	***Anaemia***	***Tuberculosis***	***BMI***
Monitor Area	-0.002	-0.018	0.007	0.014	0.003	0.225
	(0.003)	(0.020)	(0.008)	(0.010)	(0.003)	(0.371)
	Height (cm)	***Obese (BMI>30)***	***Underweight (BMI<19)***	***Amount Drink***	***Amount Smoke***	$\sum_{i=heart}^{tuberc.} health_i$
Monitor Area	-0.007	0.019	-0.004	0.039	-0.551	0.061
	(0.004)	(0.023)	(0.008)	(0.100)	(0.510)	(0.072)

Table 5. Reduced form estimates of Residence in Contaminated Zone on Labour Market Outcomes

	2003		Pooled random effects, 2003, 4, 7	
	In Work	**Log Monthly Wage**	**In Work**	**Log Monthly Wage**
i) Area Dosage>37 KBqm^2	-0.024	-0.051	-0.060	-0.011
	(0.034)	(0.051)	(0.029)*	(0.057)
ii) Monitor Area_then	-0.023	0.003	-0.072	-0.053
	(0.031)	(0.057)	(0.026)*	(0.051)
	Hours>=0	**Hours>0**	**Hours>=0**	**Hours>0**
i) Area Dosage>37 KBqm^2	-2.371	-1.370	-4.629	-2.749
	(1.578)	(1.265)	(1.248)*	(0.939)*
ii) Monitor Area_then	-3.531	-2.775	-4.479	-1.841
	(1.351)*	(0.893)*	(0.113)*	(0.796)*
	Informal Work		**Informal Work**	
i) Area Dosage>37 KBqm^2	-0.019	-0.001	-0.033	-0.027
	(0.010)	(0.033)	(0.007)*	(0.028)
ii) Monitor Area_then	-0.022	0.021	-0.030	-0.026
	(0.013)	(0.029)	(0.009)*	(0.027)

Notes; Source ULMS. Each regression also controls for region of residence, age, gender, religion, ethnicity and parental education. Sample restricted to ages 23-59.
Sample sizes in 2003 are 5302 (total), 3041 (women), 2261 (men) for working age population, 2968 (total), 1611 (women), 1367 (men) for in work population.
*= significant at the 5% level.

Table 6. Effect of Residence in Contaminated Zones on Other Outcomes

	2003		Pooled random effects, 2003, 4, 7	
	Single	**Divorced**	**Single**	**Divorced**
i) Area Dosage>37 KBqm^2	-0.015	-0.013	0.002	-0.024
	(0.017)	(0.020)	(0.017)	(0.018)
ii) Monitor Area	-0.001	0.031	-0.013	0.001
	(0.019)	(0.020)	(0.019)	(0.018)
	No. of Children	**Years of Education**	**No. of Children**	**Years of Education**
ii) Area Dosage>37 KBqm^2	0.109	-0.043	0.097	-0.003
	(0.071)	(0.067)	(0.068)	(0.078)
iii) Monitor Area	0.018	-0.059	-0.031	-0.005
	(0.062)	(0.059)	(0.059)	(0.078)
	Any Move	***Move region***	***Any Move***	***Move region***
ii) Area Dosage>37 KBqm^2	-0.032	-0.021	0.002	-0.037
	(0.031)	(0.024)	(0.016)	(0.087)
iii) Monitor Area	-0.111	-0.078	-0.029	-0.052
	(0.030)*	(0.027)*	(0.015)	(0.018)*

Notes; Source ULMS. Each regression also controls for region of residence, age, gender, religion, ethnicity and parental education. Sample restricted to ages 23-59. Sample size 5303 in 2003.

Figure A1. Employment Rate by Age, Gender & Health Status, Ukraine 2003/4

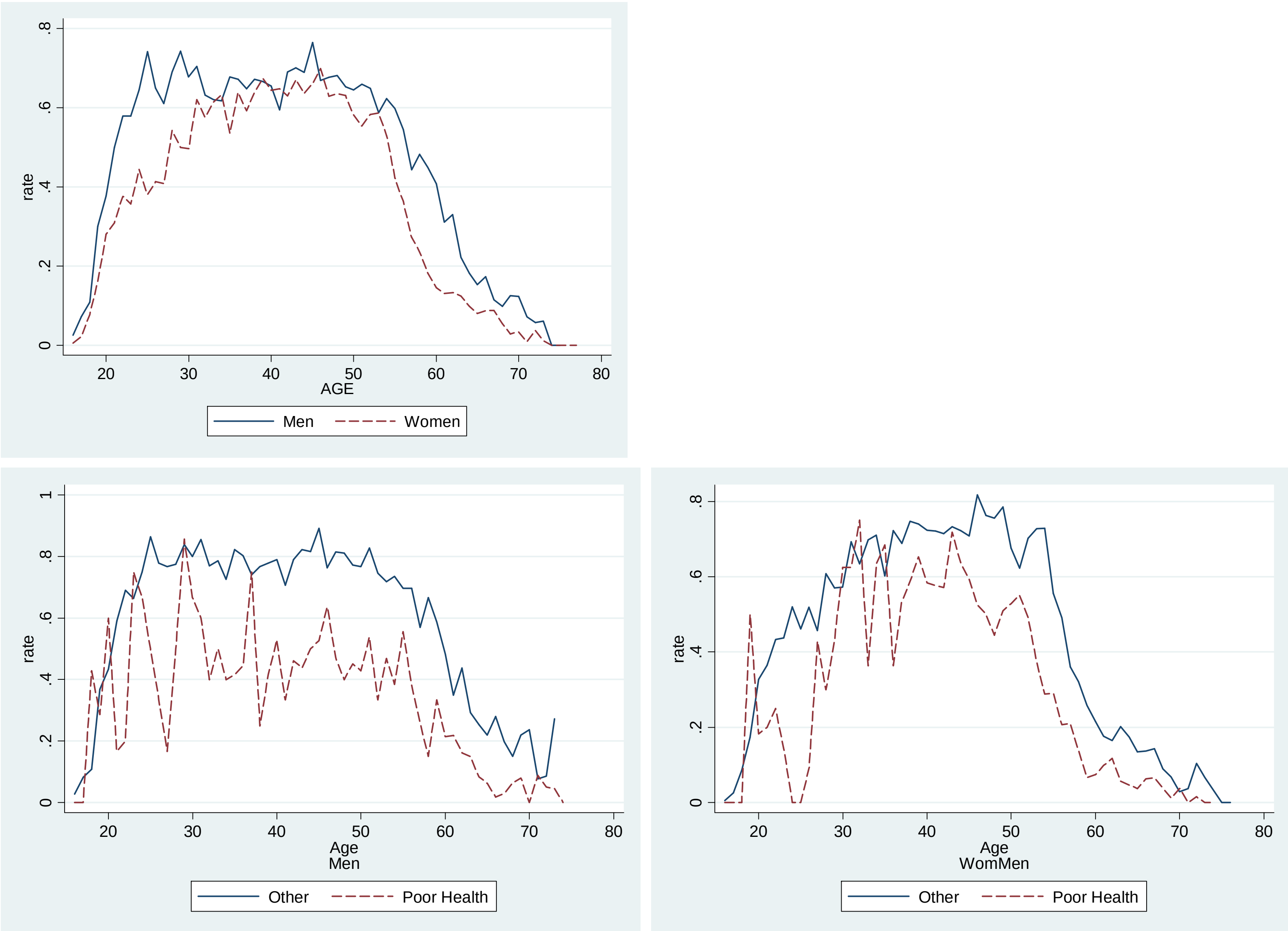

Table A2. Self-reported Health Status

	2003			Pooled		
	Total	***male***	***female***	***Total***	***male***	***female***
All Adults						
Very Good	1.7	2.7	0.9	1.7	2.6	1.0
Good	22.6	30.0	17.1	23.2	29.9	18.4
Average	53.0	50.0	55.2	52.4	49.8	54.2
Bad	22.8	17.3	26.8	21.9	17.7	26.4
Age 23-59						
Very Good	1.4	2.4	0.6	1.5	2.5	0.8
Good	23.7	32.2	17.3	25.2	32.6	19.9
Average	58.0	52.3	62.4	57.1	52.0	60.8
Bad	16.9	13.2	19.7	16.2	13.0	18.6

Source:ULMS.

Table A3. Self-reported Health Across Waves Age 23-59

		2004				2007			
		Very Good	Good	Average	Bad	Very Good	Good	Average	Bad
	Very Good	17.7	56.5	22.6	3.2	10.4	56.3	29.2	4.2
2003	Good	3.1	49.6	42.9	3.8	3.0	46.6	42.5	7.8
	Average	0.5	17.4	71.6	10.3	0.8	20.8	63.1	15.2
	Bad	0.4	3.5	44.4	51.0	0.3	8.5	41.3	42.2

Source ULMS. Entries are estimated percentage in each cell.

Table A4. Random Effects Estimates of Chernobyl-Related Variables on Gastro-intestinal illness and Heart Disease

	Age 16+			Age 23-59		
Gastro-Intestinal						
Distance (100 Km)	0.0001			0.0001		
	(0.0001)			(0.0001)		
Dosage (KBqm^2)		0.00005			0.00005	
		(0.00015)			(0.00015)	
Area Dosage>37 KBqm^2			0.013			-0.0019
			(0.016)			(0.0196)
Heart Disease						
Distance (100 Km)	0.0001			-0.00001		
	(0.0001)			(0.00001)		
Dosage (KBqm^2)		-0.00019			0.00005	
		(0.00032)			(0.00032)	
Area Dosage>37 KBqm^2			-0.0025			0.0011
			(0.0174)			(0.0020)

Table A5. Random effects Linear Probability Estimates of Health Conditions & Chernobyl Exposure Including Liquidators (Age 23-59)

	Health Status (1=v good 5=v bad)	***Any Health last 3 months***	***Smoke***	***Drink***	***Heart***	***Lung***
2003, 2004, 2007						
Monitor Area	-0.022	0.023	-0.043	-0.022	-0.045	0.002
	(0.038)	(0.025)	(0.025)	(0.025)	(0.018)*	(0.010)
Liquidator	0.300	0.110	-0.009	0.042	0.154	-0.019
	(0.063)**	(0.047)*	(0.058)	(0.044)	(0.044)**	(0.025)
	Liver	***Kidney***	***Gastrointestinal***	***Spine***	***Other***	***Diabetes***
Monitor Area	0.017	0.021	0.038	-0.008	0.012	0.003
	(0.017)	(0.015)	(0.021)	(0.018)	(0.020)	(0.010)
Liquidator	0.057	0.030	0.068	0.181	0.101	0.047
	(0.034)	(0.027)	(0.043)	(0.044)*	(0.042)*	(0.026)
	Heart Attack	***Blood Pressure***	***Stroke***	***Anaemia***	***Tuberculosis***	***BMI***
Monitor Area	-0.003	-0.024	0.010	0.012	0.002	0.392
	(0.006)	(0.019)	(0.008)	(0.009)	(0.004)	(0.302)
Liquidator	0.031	0.102	0.021	0.026	0.006	1.048
	(0.028)	(0.045)*	(0.020)	(0.017)	(0.017)	(0.563)
	Height (cm)	***Obese (BMI>30)***	***Underweight (BMI<19)***	***Amount Drink***	***Amount Smoke***	$\sum_{i=heart}^{tuberc.} health_i$
Monitor Area	-0.008	0.037	-0.003	-0.007	-0.807	0.036
	(0.004)*	(0.024)	(0.008)	(0.106)	(0.490)	(0.069)
Liquidator	0.013	0.114	-0.004	0.083	-0.906	0.803
	(0.007)	(0.029)*	(0.003)	(0.195)	(1.109)	(0.174)**

Table A6. Full Set of Linear Probability Estimates of Poor Health

	Bad Health	Amount drunk	Heart Problems
Monitor zone in 1986	0.108	0.009	-0.039
	(4.04)**	(0.09)	(1.74)
AGE	-0.004	-0.037	-0.010
	(0.97)	(1.91)	(2.68)**
AGE squared	0.001	0.001	0.001
	(2.89)**	(2.62)**	(4.44)**
Female	0.063	1.416	0.100
	(6.31)**	(28.92)**	(11.19)**
Russian	0.021	-0.204	0.006
	(1.48)	(3.01)**	(0.47)
Other ethnicity	-0.019	0.100	0.010
	(0.79)	(0.81)	(0.42)
Orthodox	0.016	-0.015	0.038
	(1.25)	(0.24)	(3.25)**
Other religion	0.002	0.254	-0.003
	(0.12)	(3.03)**	(0.22)
Village	-0.003	0.119	0.012
	(0.22)	(2.20)*	(1.09)
Kyiv	-0.110	-0.620	0.034
	(3.81)**	(4.81)**	(1.21)
Kyivskaya	-0.066	0.228	0.072
	(1.78)	(1.40)	(2.09)*
West	-0.073	-0.207	-0.024
	(4.15)**	(2.79)**	(1.49)
East	-0.053	0.118	-0.007
	(3.30)**	(1.78)	(0.46)
South	-0.062	0.069	-0.037
	(3.37)**	(0.84)	(2.24)*
University graduate	-0.139	-0.063	-0.041
	(7.00)**	(0.71)	(2.13)*
Technical school	-0.079	-0.112	-0.037
	(4.54)**	(1.54)	(2.36)*
High school diploma	-0.033	-0.003	-0.019
	(1.65)	(0.04)	(1.04)
mother_graduate	0.001	0.068	-0.020
	(0.05)	(0.62)	(1.06)
Mother_high school	-0.003	0.038	-0.007
	(0.24)	(0.67)	(0.64)
Father_graduate	-0.008	-0.039	0.019
	(0.51)	(0.42)	(1.10)
linguist	-0.004	-0.127	-0.017
	(0.30)	(2.35)*	(1.56)
Left handed	0.016	-0.163	0.071
	(0.47)	(1.05)	(2.06)*
Constant	0.152	5.855	0.146
	(1.68)	(14.66)**	(1.97)*

Note sample size 5203. t statistics in brackets.

Table. A7. Estimated Sample Attrition Probabilties (Marginal effects)

	Drop Out	Drop Out
Monitor zone in 1986	0.030	-0.037
	(0.021)	(0.023)
AGE		-0.005
		(0.004)
AGE squared		0.000
		(0.000)
Female		-0.029
		(0.011)**
Russian		-0.000
		(0.015)
Other ethnicity		-0.051
		(0.023)*
Orthodox		-0.065
		(0.014)**
Other religion		-0.059
		(0.015)**
Village		-0.112
		(0.011)**
Kyiv		0.246
		(0.045)**
Kyivskaya		0.156
		(0.052)**
West		0.176
		(0.024)**
East		0.032
		(0.019)
South		0.280
		(0.027)**
University graduate		0.020
		(0.022)
Technical school		0.002
		(0.017)
High school diploma		0.006
		(0.019)
Mother_graduate		-0.041
		(0.021)*
Mother_high school		-0.011
		(0.013)
father_graduate		0.021
		(0.021)
linguist		0.021
		(0.012)

Note marginal effects from probit estimates. Robust standard errors in brackets. * significant at 5%; ** significant at 1%. Mean of dependent variable is 0.192